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ABSTRACT

A project to develop and evaluate a bar code reader system as a self-directed information and instructional aid for handicapped nonreaders is described. The bar code technology involves passing a light sensitive pen or laser over a printed code with bars which correspond to coded numbers. A system would consist of a portable device which could "read" printed bar code and a processing unit which would transcribe the code and auditorially present the information via a speech synthesizer. Twelve objectives in developing such a system are listed and discussed, including a nationwide survey to evaluate the need for this approach on the part of handicapped nonreaders and to test the system in such applications as restaurant menus for visually impaired people and emergency training for moderately and severely handicapped persons. (CL)

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ENABLING HANDICAPPED NONREADERS TO INDEPENDENTLY OBTAIN INFORMATION: INITIAL DEVELOPMENT OF AN INEXPENSIVE BAR CODE READER SYSTEM

ALAN VANBIERVLIET

ABSTRACT

A large number of mentally retarded, physically handicapped, and visually impaired persons are unable to obtain information from the available symbol systems (i.e., printed words and numbers). Those individuals remain unduly dependent upon other for their information needs. The primary purpose of this project is to evaluate an inexpensive, reliable, portable bar code reader that transcribes printed bar code into synthetic speech. These bar code readers will enable handicapped persons to independently gain information and retrieve seldom-used or forgotten information. For example, this technology will enable handicapped nonreaders to "read" recipes, menus, first aid instructions, bus schedules, and board game rules. For many years, this technology has been used to obtain reliable information for merchandise inventory and sales. This project will first evaluate the durability of the reader and the intelligibility of its synthetic speech. Following these experiments, the efficacy of using the bar code reader as an aid in learning meal preparation and emergency skills will be examined using a combined alternating treatments and multiple baseline design. In addition, the device will be evaluated in regard to its usefulness as a teaching aid for handicapped readers using an alternating treatments design. The use of a bar code reader as an efficient, self-operated information retrieval device appears promising and deserves careful development and evaluation. Bar code readers have the potential for increasing the independence of a large number of handicapped individuals. This project represents the first examination of the application of bar code reader technology as a practical aid for handicapped nonreaders.

Importance of Program

Written language and other standard symbol systems are available to most individuals for obtaining information. A large number of handicapped individuals, however, are functionally illiterate of their ability to gain information from the available symbol systems. This includes many mentally retarded, physically handicapped, visually impaired, and other handicapped persons. Sartain (1976) has estimated that 13 to 15 percent of the population of the United states is illiterate. Without the use of a functional symbol system, many handicapped persons will forever remain unduly dependent upon others for their information needs. Most available self-instructional aids in daily living (e.g., cookbooks), work (e.g., automotive manuals), and leisure (e.g., board game rules and theater schedules) are designed to be read, thus perpetuating the handicapped nonreader's dependency.

The development of an effective system for independently gaining information from a variety of sources is a critical need for many handicapped persons who cannot read. These individuals need a means to gain new information and retrieve seldom-used or forgotten information.

Alternative Information Systems

Braille:

Braille has been developed as an alternative symbol system to circumvent some of the debilitating effects of visual deficits. However, Braille

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requires very fine tactile discrimination skills. It has been estimated that only about 4 percent of the legally blind individuals in the U.S.A. learn to effectively use Braille (American Foundation for the Blind, 1981).

Pictorial instruction:

One alternative symbol system that has been successfully used to teach moderately and severely handicapped individuals is called picture reading or pictorial instruction. Pictorial instruction involves teaching individuals to obtain information and instructions from simple pictures sometimes accompanied by printed words (Spellman, DeBriere, Jarboe, Campbell, & Harris, 1978). When cued by pictures, learners are taught to select items, perform specific actions, "read" the pictures in an ordered sequence, and perform actions in the order depicted. Learners who have acquired the skills to follow pictorial instruction may be able to use picture books to solve problems and to learn new tasks. Picture books can also be used as reminders of how a task is performed. Pictorial instruction has been used successfully to teach a wide range of skills including: meal preparation (Johnson & Cuvo, 1981); Martin, Rusch, James, Decker, & Trtol, 1982; Robinson-Wilson, 1977), housekeeping skills (Spellman et al., 1978), schedule and calendar skills (Spellman et al., 1978), public transportation skills (Vogelsberg & Rusch, 1980), and vocational skills (Wacker & Berg, 1983). Although many moderately and severely handicapped individuals have learned to use picture skills, some younger and more severely handicapped individuals never learned to use the picture cue system (Spellman et al., 1978). As an alternative symbol system, pictorial instruction has several disadvantages. These are: 1) many actions and objects are very difficult to depict by a picture or photograph; 2) some individuals do not learn to translate pictorial symbols into actions; 3) the system is of little benefit for severely visually impaired persons; and 4) currently there are neither standard rules governing what symbols to use nor rules concerning the syntactic arrangement of the symbols.

Audio cassette players:

Another procedure for obtaining information is to store the information on cassette tapes which can be played back at any time. Perera and Cobb (1978) described the Learning Through Listening Project which used tape-recorded materials for teaching visually impaired students. The "Talking Book" system also uses this procedure. Many visually impaired persons use cassette players to store and retrieve information on a daily basis (e.g., university students use this procedure for taking class notes). This procedure enables handicapped individuals to access information in a wide variety of settings with reliable, inexpensive equipment. The primary disadvantage of this alternative is that the searching and scanning skills that are necessary to find a particular piece of information on a tape are too complex for many handicapped persons.

Hi-tech converters:

Several devices have been developed to convert text into either auditory or tactile stimuli for visually impaired persons. Examples of these devices are the Kurzweil Reading Machine which produces synthetic speech from printed materials (Goodrich, Bennett, De L'Aune, Lauer, & Mowinski, 1979; Selvin, 1981) and the Optacon which produces a tactile stimulus to the reader's fingertip (Moore & Hunt, 1981; Thurman & Weiss-Kapp, 1977). These devices, however, are fairly fragile, require considerable skill and training to use (particularly the Optacon), and they are beyond the financial range of most handicapped persons (costing from $3,000 to $52,000).

Bar code readers:

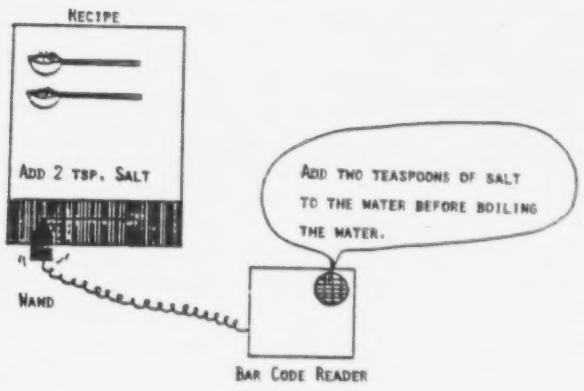
Another strategy for effectively obtaining information from a variety of sources is the use of bar code reader technology. For many years this technology has been used to obtain reliable information for merchandise inventory and sales. Basically this system involves passing a light sensitive pen or laser over a printed code containing bars of varying thickness which correspond to coded numbers. This bar code can be printed anywhere on an item. Information regarding the product that is stored in the machine's memory can then be accessed and presented via a visual display, printed on paper, or spoken aloud with the aid of a voice synthesizer.

An information system for handicapped persons would consist of a portable device which could "read" printed bar code from a variety of sources. The processing unit would then transcribe the code and auditorily present the information via a speech synthesizer.

FIGURE 3.

BAR CODE READERS

INVOLVES PASSING A LIGHT SENSITIVE PEN OR WAND OVER PRINTED CODE CONTAINING BARS OF VARYING THICKNESS. THE DEVICE TRANSCRIBES THE CODE INTO AUDITORY STIMULI.



Method

At present, however, there is no application of this technology to the information needs of handicapped persons. The primary purpose of this research project is to develop and evaluate a bar code reader system as a self-directed information and instructional aid for handicapped persons.

Objective 1. To repackage the Magic Wand so that it meets the functional and aesthetic needs of handicapped persons.

The first task will involve putting the Magic Wand mechanism into a smaller less obtrusive package. The new "box" should be no bigger than 10 by 10 by 4 cm. This task can be accomplished by either utilizing commercially available universal boxes, or creating out of plastic or metal a custom built package. In addition, the power source will be converted from 4 D-cell batteries to a more compact battery source.

Objective 2. To examine the performance of the Magic Wand under a variety of climatic conditions.

In order to be a truly useful adaptive aid, the bar code reader must be able to function correctly under a wide variety of climatic conditions. The Magic Wand will be tested under cold (below 0 F), hot (above 100 F), high humidity (99%), low humidity (3%), and at various atmospheric pressures. Performance tests will also be conducted under **fluctuating** temperature and humidity conditions as would occur when moving in and out of buildings. In addition, performance tests will be conducted following shocks and impacts resulting from dropping the device form table height up to ten occasions.

The performance tests will be conducted using simple ABAB designs with each condition lasting approximately 30 minutes. Transcription or misreading errors and the rate of synthetic word production will be recorded under each condition. These results will be compared to the performance data on the Magic Wand which are available from Texas instruments.

Objective 3. To evaluate the ability of learning disabled, visually impaired, moderately handicapped, and severely handicapped persons to comprehend the synthesized speech produced by the Magic Wand.

Over the past few years, there has been a rapid growth in voice response devices using synthetic speech. As the number of products that incorporate voice output increases in the educational and rehabilitation marketplace, there is a great need for data about handicapped individuals abilities to comprehend and understand synthetic speech. At the present time, however, there is very little information in the literature dealing with how handicapped persons perceive and understand synthetic speech. The few research reports that are available deal solely with visually impaired children's and adults' abilities to comprehend synthetic speech (Brabyn & Brabyn, 1982; Goodrich, Bennett, Paul, & Wiley, 1980; Rhyne, 1982; Scadden, 1978). The present research study is designed to extend this line of research by involving learning disabled, moderately and severely handicapped, as well as visually impaired young adults and elder citizens. It is intended that this research project will serve to facilitate the development of a comprehensive series of research activities in this area. The research methods that are described below have been adapated from the procedures that have been used at the Speech Research Laboratory at Indiana University to study the perception of synthetic speech by nonhandicapped children (Greene and Pisoni, 1982) and adults (Luce, Feustel, & Pisoni, 1981).

Twelve learning disabled, twelve moderately handicapped, twelve severely handicapped, twelve legally blind young adults and twelve legally blind elder citizens will participate in this experiment. All participants will have normal hearing and they will be native speakers of English. The learning disabled and visually handicapped persons will participate in a work list recall test, the moderately handicapped persons will participate in a Peabody Picture Vocabulary Test, and the severely handicapped persons will participate in a verb-noun instruction following task. Each of the activities will be repeated on two separate occasions. Four sets of words or phrases will be developed for each separate task. One set will be recorded by a male native English speaker. The remaining three will be recorded via the Magic Wand's speech synthesizer at three different pitch levels.

Objective 4: To evaluate handicapped nonreaders need for a device such as a bar code reader on a national basis.

This objective will be achieved by the development, distribution, and analysis of a questionnaire. The questionnaires, will ask special educators to supply information regarding their students' reading skills, ability to use alternative symbol systems, and their information needs. The information produced by this survey will help guide the development of the bar code reader system.

Objective 5: To develop, implement, and evaluate a program to teach moderately and severely handicapped persons to use the Magic Wand to prepare

complex meals.

Three to six moderately or severely handicapped young adults will participate in this Experiment. Pictorial instruction booklets (Johnson, 1977; Staples, 1975) will be prepared for nine different recipes. Bar-code instructions will be created for each recipe. Six recipes will be randomly chosen for training in a combined alternating treatments (Barlow & Hayes, 1979) and multiple probe baseline design (Horner & Baer, 1978). The remaining three recipes will serve as generalization probes. At each leg of the multiple baseline one recipe will be randomly chosen to be taught using a bar code reader procedure and the other will be taught using a pictorial instruction procedure (Spellman et al., 1978). Training will occur on one recipe per school/work day, training will systematically alternate between the two recipes. The number of teacher prompts, the number of independently performed steps, and the amount of time spent on each task will serve as the dependent variables.

Two important questions need to be asked in regards to the true value of a bar code reader system as a self-instructional aid. These are: 1) Whether following training individuals will independently use the reader to facilitate their performance across different types of tasks and settings; and 2) Whether individuals will independently use the reader to obtain reference information after long intervals during which they have "forgotten" how to complete a task. These questions will be answered by conducting unreinforced probes both during the training period and following the termination of training. If the handicapped individual is unsuccessful in these probes, the individual will be trained on a selected probe item. This sequence of probing then training will continue until generalization is evident.

Objective 6. To evaluate the effectiveness of bar coded recipes for use by visually impaired persons.

Twenty visually impaired persons will participate in this Experiment. These individuals will possess cooking skills, however, they will not have mastered Braille reading. Six recipes chosen from a cookbook written for visually impaired cooks will be transcribed into bar code instructions. The bar code will have raised edges so that it can be easily located tactically. Following brief instructions in the use of the device, each participant will be observed attempting to complete the recipe in their own kitchen. Observation data will be recorded including the amount of time spent on the recipe, the number of steps correctly followed, and the number of passes made over each bar code instruction. Following the completion of the last recipe, the participants will be asked a series of questions regarding their satisfaction with the bar code reader system.

Objective 7. To evaluate the effectiveness of bar code equipped restaurant menus for use by visually impaired persons.

Menus at a restaurant near the University Campus will be provided with bar coded information about the selections and prices. Bar code readers will be available at the tables to read the menus. This restaurant is frequented by visually impaired individuals involved in mobility training courses. As part of the mobility training courses the students will be briefly instructed in the use of the bar code reader. An observer in the restaurant will record information on the frequency of use of the devices and the number of passes made over each bar coded selection and price. After six to eight visits, over approximately four weeks, the visually impaired individuals will be asked

a series of user satisfaction questions.

Objective 8. To develop, implement, and evaluate a program to teach moderately and severely handicapped persons to adequately behave in emergency situations.

Three to six moderately or severely handicapped young adults will participate in this Experiment. Pictorial instruction booklets will be prepared for nine first aid and emergency procedures necessary for safely living in the community such as care of burns, care of seizures (Matson, 1980), operating fire extinguishers, care of sprains, poison emergency, tornado procedures, burst water pipes, and burglary. Bar-code instructions will be created for each procedure. Six emergency procedures will be randomly chosen for training in a combined alternating treatments (Barlow & Hayes, 1979) and multiple probe baseline design (Horner & Baer, 1978). The remaining three procedures will serve as generalization probes. At each leg of the multiple baseline one procedure will be randomly chosen to be taught using a bar code reader strategy and the other will be taught using a pictorial instruction strategy. Training will occur on one procedure per day, training will systematically alternate between the two procedures. The number of teacher prompts, the number of independently performed steps, and the amount of time spent on each task will serve as the dependent variables.

Objective 9. To evaluate the effectiveness of the BCRS as a procedure for mildly handicapped readers to independently preview a story.

The present Experiment is designed to serve as a pilot study to begin evaluating the effectiveness of the BCRS as a tool for reading instruction for handicapped students. It is hypothesized that the wider the range of proven educational applications of the BCRS, the more likely that costs will remain low, the device will be more widely available for purchase, and the more likely the BCRS will be adopted as a valuable educational tool and adaptive device. Promising findings from this initial experiment will serve as the starting point for the development of a more comprehensive series of research activities.

Several prereading activities have proven to be effective in improving handicapped students' reading comprehension (Sachs, 1983) and oral reading behavior (Rose, 1984; Singh & Singh, 1984; Wong & McNaughton, 1980). These strategies have included the teacher providing short verbal statements about the story (Smith & Hess, 1969), and conceptual statements relating to the theme of the story (Bransford & Johnson, 1972). This Experiment is designed to evaluate the effectiveness of using the BCRS for previewing a story before orally reading it.

Six normally hearing 9 to 12 year old students school-classified as mildly retarded or learning disabled will participate in this study. The study will be conducted in a resource room by the classroom teacher. Stories of approximately 100 words from the school's basal reading series will provide the reading material for the study. The stories will be matched to the students' tested reading levels. Preview scripts for these stories will be prepared and transcribed into bar code. These scripts will be designed to provide a background to the story, provide a brief description of the story, and introduce new words, phrases, and expressions.

An alternating treatments design (Barlow & Hayes, 1979; Kazdin & Hartman, 1978) will be used to compare the effects of two training conditions (see Figure 2). The two training conditions will consist of the student independently previewing the story via BCRS, and the teacher reading

the preview script to the student. The design will be limited to only two different training procedures since it has been suggested that the number of independent variables in an alternating treatments design be limited to two in order to facilitate subsequent data analysis (Hartmann, Shigetomi, & Barrios, 1978).

The students' oral reading of the stories will be observed and recorded by the teacher and audiotaped for rating by a second observer. Two mutually exclusive responses will be recorded: oral reading errors defined as a mismatch between text and the child's oral response, and self corrections defined as the child's spontaneous correction of oral reading errors without teacher assistance. Following the completion of a story, the teacher will orally administer a comprehension test. Each test will consist of 12 items evenly divided across four levels of reading comprehension: literal, inferential, evaluative, and appreciative according to Barrett's taxonomy (1976). The reliability and content validity of the comprehension test will be evaluated using the procedures described by Sachs (1983). The resulting data will be presented graphically for visual analysis and statistical tests such as analyses of variance will be conducted.

Objective 10. To determine the preliminary costs and benefits of a bar code reader system in order to associate a dollar figure with the system's outcome.

A major obstacle to the adoption of any new procedure is the cost, or imagined cost, of its adoption; it is incumbent upon rehabilitation and education innovators to provide the estimated cost of adopting their procedures. Accordingly, the costs of the bar code reader system will be analyzed. These cost estimates will include the price of the equipment, costs of producing bar coded materials, and the costs associated with training individuals to use the readers. In addition, savings resulting from the use of the procedures, including savings in training time, staff time, and increases in independence will be estimated.

Objective 11. To prepare a report of the research findings, and to prepare documentation for the training programs that have been developed for the bar code reader system.

This component of the Project will involve writing a final report containing an analysis of the significance of the Project and an assessment of the degree to which the objectives of the project have been achieved. In addition, detailed descriptions and instructions for bar code reader training programs in the areas of meal preparation and emergency procedures will be produced. This program documentation will be written in such a way that someone unfamiliar with the bar code reader system could effectively conduct meal preparation and emergency care training with other handicapped persons.

Objective 12. To disseminate research findings and developed materials nationally.

This objective is directly related to the function of scholarly productivity and the sharing with professionals and other interested persons information, strategies, and technologies that will lead to better services for handicapped individuals. Descriptions of the project and resulting scientific findings will be presented at relevant national and regional conventions. Information about the project will also be published in scientific and practice oriented journals. In addition,

information will be disseminated through the ERIC database, and federally funded dissemination projects.

Conclusion

The bar-code reader system should prove to be a time-efficient procedure for promoting self-control and independence. The system provides antecedent stimuli in the form of auditory instructions or information which handicapped individuals can independently manipulate to guide their performance. The bar-code reader system should permit individuals to have greater control over their environments, and reduce the need for major environmental adaptations.

It should also facilitate the generalization and maintenance of new skills. The bar-code reader provides stable discriminative stimuli which handicapped individuals can use to guide their performance across diverse settings, tasks, and time. In addition, the bar-code reader system is potentially efficient because: a) it is easily used in new tasks and settings; b) it is easily adapted to meet differing information needs; and c) its use will likely produce a reduction in training time. The use of bar code readers as efficient, self-operated information devices appears promising and deserves careful development and evaluation. Bar code readers have the potential for increasing the independence of a large number of handicapped individuals.

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